

PROCESS FLOW CALCULATIONS
Responsiveness Summary/ ROD Backup
Lower Eight Miles of the Lower Passaic River

Legend

data grouping

inputs/assumptions

TSI Assumptions - Appendix E Attachment 2

output for process flow diagrams

Calculations based on methodology found in Pre-Final Design Analysis Report Phase I Removal Action by Tierra Solutions, Inc. (TSI)
Appendix E Attachment 2.

Parameter		Selected Remedy			Basis/Assumption	
		Alt 2	Alt 3	Alt 4	Units	
Operational Data						
V ₁	Dredged sediment in-situ volume	9,712,347	3,541,588	1,021,263	cy	Volume Current as of October 8, 2015.
t _{h/d}	Dredge and sediment processing plant operating time	24	24	24	hr/d	
t _{d/w}	Dredge operating days per week	6	6	6	days/wk	
t _{w/y}	Dredging weeks per year	32	32	32	wks/yr	35 weeks construction season minus 3 weeks downtime
P _{cy/d}	In-situ daily production rate	3,850	3,850	3,850	cy/day	combined production rate for all dredges in operation; number and size of dredges will vary over project location and schedule
t	Project duration (including downtime)	4,796	1,749	504	days	project duration (including downtime)
In-situ Sediment						
p _w	Density of water	62.4	62.4	62.4	lb/ft3	
G _s	Specific gravity of solids	2.54	2.35	2.35	--	Alt 2: TSI assumption - Dredging depth are higher (more consolidated sediment); Alts 3 & 4: Based on top 3-feet sediment - FFS App G Fact Sheet
%S ₁	Percent solids by weight	50	42.5	42.5	%	Alt 2: TSI assumption - Dredging depth are higher (more consolidated sediment); Alts 3 & 4: Based on top 3-feet sediment - FFS App G Fact Sheet
w ₁	Water content	100.0	135.3	135.3	%	w ₁ = W _w /W _s = 100*(100-%S ₁)/%S ₁
e ₁	Void ratio	2.54	3.18	3.18	--	e ₁ = V _v /V _s = W _w /W _s *G _s /100 = w ₁ *G _s /100
p _{d1}	Dry bulk density	44.8	35.1	35.1	lb/ft3	p _{d1} = G _s *p _w / (1+e ₁)
p ₁	Wet bulk density	89.6	82.6	82.6	lb/ft3	p ₁ = p _{d1} * (1+w ₁)
Debris Removal						
%debris	Percent debris by volume (med/small sized only)	6	6	6	%	TSI assumption - can vary from 6% - 10%
V _d	Volume of debris	582,741	212,495	61,276	cy	V _d = % _{debris} * V ₁
V ₂	In-situ volume after debris removal	9,129,606	3,329,093	959,987	cy	V ₂ = V ₁ - V _d
W ₂	In-situ sediment mass after debris removal	11,041,793	3,712,075	1,070,425	tons	W ₂ = V ₂ * p ₁
Mechanically Removed Sediment						
%S ₃	Solids content after dredging (in scow)	35	30	30	%	Assumption/Professional Judgement
w ₃	Water content	186	233	233	%	w ₃ = 100*(100-%S ₃)/%S ₃
e ₃	Void ratio	4.72	5.48	5.48	--	e ₃ = w ₃ *G _s /100
b _{f3}	Bulking factor	1.62	1.55	1.55	--	b _{f3} = (e ₃ +1) / (e ₁ +1)
-	Volume after dredging (debris included)	15,685,558	5,493,906	1,584,239	cy	= V ₁ * b _{f3}
V ₃	Volume after dredging (debris removed)	14,744,425	5,164,272	1,489,185	cy	V ₃ = V ₂ * b _{f3}
Hydraulic Off-Loading						
%S ₄	Solids content	10	10	10	%	Assumption/Professional Judgement
w ₄	Water content	900	900	900	%	w ₄ = 100*(100-%S ₄)/%S ₄
e ₄	Void ratio	22.9	21.2	21.2	--	e ₄ = w ₄ *G _s /100
p _{d4}	Dry bulk density	6.6	6.6	6.6	lb/ft3	p _{d4} = G _s *p _w / (1+e ₄)
p ₄	Wet bulk density	66.5	66.2	66.2	lb/ft3	p ₄ = p _{d4} * (1+w ₄)
b _{f4}	Bulking factor	6.74	5.30	5.30	--	b _{f4} = (e ₄ +1) / (e ₁ +1)
-	Total hydraulically off-loaded slurry volume (debris included)	65,462,316	18,769,669	5,412,478	cy	= V ₁ * b _{f4}
V ₄	Total hydraulically off-loaded slurry volume (debris removed)	61,534,577	17,643,489	5,087,730	cy	V ₄ = V ₂ * b _{f4}
V _{w1}	Dilution water (water added to make slurry)	9,451,610,853	2,520,801,815	726,906,016	gallons	V _{w1} = V ₄ - V ₃ * 202 gal/cy
Sand Removal						
% _{sand}	In-situ percent sand by weight	23.4	23.4	23.4	%	Assumption - FFS App G Fact Sheet
W _{sand1}	In-situ mass of sand	2,583,780	868,626	250,479	wet tons	W _{sand1} = % _{sand} /100 * W ₂
V _{sand1}	In-situ volume of sand	2,136,328	779,008	224,637	wet cy	V _{sand1} = W _{sand1} /p ₁

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Selected Remedy						Basis/Assumption
Parameter	Alt 2	Alt 3	Alt 4	Units		
W_{fines1}	In-situ mass of fine-grained sediment	8,458,013	2,843,450	819,946	wet tons	$W_{fines1} = (1 - \%_{sand}) / 100 * W_2$
V_{fines1}	In-situ volume of fine-grained sediment	6,993,278	2,550,085	735,350	wet cy	$V_{fines1} = W_{fines1} / \rho_1$
$\%S_5$	Hydrocyclone underflow (wet sand) percent solids	60	60	60	%	TSI assumption - can vary from 55% - 65%
w_5	Water content	67	67	67	%	$w_5 = 100 * (100 - \%S_5) / \%S_5$
e_5	Void ratio	1.69	1.57	1.57	--	$e_5 = w_5 * G_s / 100$
bf_5	Shrinkage factor	0.76	0.61	0.61	--	$bf_5 = (e_5 + 1) / (e_1 + 1)$
V_5	Wet sand volume	1,625,379	478,405	137,954	wet cy	$V_5 = V_{sand1} * bf_5$
pd_5	Dry sand bulk density	58.9	57.2	57.2	lb/ft3	$pd_5 = G_s * \rho_w / (1 + e_5)$
p_5	Wet sand bulk density	98.1	95.3	95.3	lb/ft3	$p_5 = pd_5 * (1 + w_5)$
W_5	Dry mass of sand	1,291,890	369,166	106,454	dry tons	$W_5 = V_5 * pd_5$
Sand Dewatering						
$\%S_6$	Sand percent solids after dewatering	80	80	80	%	TSI assumption - can vary from 75% - 85%
w_6	Water content	25	25	25	%	$w_6 = 100 * (100 - \%S_6) / \%S_6$
e_6	Void ratio	0.64	0.59	0.59	--	$e_6 = w_6 * G_s / 100$
bf_6	Dewatered sand shrinkage factor	0.46	0.38	0.38	--	$bf_6 = (e_6 + 1) / (e_1 + 1)$
V_6	Dewatered sand volume	986,694	295,897	85,326	wet cy	$V_6 = V_{sand1} * bf_6$
pd_6	Dry dewatered sand bulk density	97.0	92.4	92.4	lb/ft3	$pd_6 = G_s * \rho_w / (1 + e_6)$
p_6	Wet dewatered sand bulk density	121.2	115.5	115.5	lb/ft3	$p_6 = pd_6 * (1 + w_6)$
W_6	Mass of dewatered sand	1,614,862	461,457	133,067	tons	$W_6 = V_6 * p_6$
De-sanded Slurry						
$\%S_7$	Slurry percent solids	7.9	7.9	7.9	%	$\%S_7 = \text{de-sanded slurry dry weight} / (\text{de-sanded slurry wet weight} + \text{weight of water from de-watering})$
w_7	Water content	1,161	1,162	1,162	%	$w_7 = 100 * (100 - \%S_7) / \%S_7$
e_7	Void ratio	29.5	27.3	27.3	--	$e_7 = w_7 * G_s / 100$
bf_7	Bulking factor	8.61	6.77	6.77	--	$bf_7 = (e_7 + 1) / (e_1 + 1)$
V_7	De-sanded slurry volume	60,242,687	17,274,323	4,981,276	wet cy	$V_7 = V_{fines1} * bf_7$
pd_7	De-sanded slurry dry bulk density	0.07	0.07	0.07	dry tons/cy	$pd_7 = G_s * \rho_w / (1 + e_7)$
p_7	De-sanded slurry wet bulk density	0.89	0.88	0.88	ton/cy	$p_7 = pd_7 * (1 + w_7)$
W_7	Mass of de-sanded slurry	53,336,882	15,253,111	4,398,433	tons	$W_7 = V_7 * p_7$
W_{7-dry}	Dry mass of de-sanded slurry	4,229,007	1,208,466	348,477	dry tons	$W_{7-dry} = V_7 * pd_7$
Slurry Conditioning						
Q_{pt}	Polymer flow rate to gravity thickener	40	40	40	gpm	TSI assumption
$\%S_{pt}$	Polymer solids content by weight	0.25	0.25	0.25	%	TSI assumption
V_{pt}	Volume of polymer	276,234,285	100,728,282	29,046,311	gal	$V_{pt} = Q_{pt} * 60 \text{ min/hr} * t_{h/d} * t$
W_{pt}	Mass of polymer	1,152,761	420,352	121,214	tons	$W_{pt} = V_{pt} * \text{conversions}$
W_{pt-dry}	Polymer dry solids	2882	1051	303	dry tons	$W_{pt-dry} = \%S_{pt} * W_{pt} / 100$
Q_{clr}	Clarifier solids flow rate	25	25	25	gpm	TSI assumption
$\%S_{clr}$	Clarifier solids content	0.13	0.13	0.13	%	TSI assumption
V_{clr}	Volume of clarifier solids	172,646,428	62,955,176	18,153,945	gal	$V_{clr} = Q_{clr} * 60 \text{ min/hr} * t_{h/d} * t$
W_{clr}	Mass of clarifier solids	720,476	262,720	75,759	tons	$W_{clr} = V_{clr} * \text{conversions}$
$W_{clr-dry}$	Clarifier dry solids	937	342	98	dry tons	$W_{clr-dry} = \%S_{clr} * W_{clr} / 100$
Gravity Thickener						
$\%S_8$	Percent solids	7.7	7.6	7.6	%	$= (\text{dry weight of desanded slurry} + \text{polymer} + \text{clarifier}) / (\text{total weight of desanded slurry} + \text{polymer} + \text{clarifier}) * 100$

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w ₈	Water content	1,204	1,217	1,217	% $w_8 = 100 * (100 - \%S_8) / \%S_8$
e ₈	Void ratio	30.59	28.60	28.60	-- $e_8 = w_8 * Gs / 100$
V ₈	Gravity thickener influent volume	62,464,869	18,084,637	5,214,940	cy $V_8 = V_7 + (V_{pt} + V_{clr}) / 202 \text{ gal/cy}$
W ₈	Mass of de-sanded slurry	55,210,118	15,936,183	4,595,406	tons $W_8 = W_7 + W_{pt} + W_{clr}$
W _{8-dry}	Dry mass of de-sanded slurry	4,232,825	1,209,858	348,878	dry tons $W_{8-dry} = W_{7-dry} + W_{pt-dry} + W_{clr-dry}$
Thickened Slurry					
%S ₉	Percent solids (S%)	15	15	15	% TSI assumption
w ₉	Water content (w)	567	567	567	% $w_9 = 100 * (100 - \%S_9) / \%S_9$
e ₉	Void ratio (e)	14.39	13.32	13.32	-- $e_9 = w_9 * Gs / 100$
bf ₉	Shrinkage factor	0.49	0.48	0.48	-- $bf_9 = (e_9 + 1) / (e_8 + 1)$
V ₉	Thickened slurry volume	30,438,148	8,745,819	2,521,971	cy $V_9 = V_8 * bf_9$
V _{ow}	Gravity thickener overflow (water) volume	32,026,721	9,338,818	2,692,970	cy $V_{ow} = V_8 - V_9$
%S _{ow}	Target water treatment influent solids content (S%)	0.005	0.005	0.005	% TSI assumption
W _{ow}	Gravity thickener overflow (water) mass	26,992,281	7,870,803	2,269,648	tons $W_{ow} = V_{ow} * 0.842 \text{ tons/cy}$
W _{ow-dry}	Gravity thickener overflow (water) dry mass	1350	394	113	dry tons $W_{ow-dry} = \%S_{ow} * W_{ow} / 100$
W ₉	Thickened slurry weight	28,217,838	8,065,380	2,325,757	tons $W_9 = W_8 - W_{ow}$
W _{9-dry}	Thickened slurry dry weight	4,231,476	1,209,465	348,765	dry tons $W_{9-dry} = W_{8-dry} - W_{ow-dry}$
Mechanical Press Influent					
Q _{pp}	Polymer flow rate to presses	20	20	20	gpm TSI assumption
V _{pp}	Volume of polymer	138,117,142	50,364,141	14,523,156	gal $V_{pp} = Q_{pp} * 60 \text{ min/hr} * t_{h/d} * t$
W _{pp}	Mass of polymer	576,266	210,134	60,595	tons $W_{pp} = V_{pp} * \text{conversions}$
W _{pp-dry}	Mass of polymer dry solids	1441	525	151	dry tons $W_{pp-dry} = \%S_{pp} * W_{pp} / 100$
V ₁₀	Mechanical press total influent volume	31,121,896	8,995,146	2,593,867	wet cy $V_{10} = V_9 + V_{pp}$
W ₁₀	Mechanical press total influent wet weight	28,794,104	8,275,515	2,386,352	tons $W_{10} = W_9 + W_{pp}$
%S ₁₀	Percent solids (S%)	14.7	14.6	14.6	% $= 100 * (\text{thickened slurry weight} + \text{polymer dry weight}) / (\text{thickened slurry wet weight} + \text{polymer wet weight})$
w ₁₀	Water content (w)	580	584	584	% $w_{10} = 100 * (100 - \%S_{10}) / \%S_{10}$
e ₁₀	Void ratio (e)	14.74	13.72	13.72	-- $e_{10} = w_{10} * Gs / 100$
Mechanical Press Dewatered Sediment					
%S ₁₁	Target percent solids (S%)	57.5	57.5	57.5	% TSI assumption
w ₁₁	Water content (w)	74	74	74	% $w_{11} = 100 * (100 - \%S_{11}) / \%S_{11}$
e ₁₁	Void ratio (e)	1.88	1.74	1.74	-- $e_{11} = w_{11} * Gs / 100$
bf ₁₁	Shrinkage factor	0.18	0.19	0.19	-- $bf_{11} = (e_{11} + 1) / (e_{10} + 1)$
V ₁₁	Dewatered sediment volume	5,689,982	1,672,235	482,211	wet cy $V_{11} = V_{10} * bf_{11}$
V _{fp}	Mechanical press filtrate water volume	25,431,914	7,322,911	2,111,657	cy $V_{fp} = V_{10} - V_{11}$
W _{fp}	Filtrate water weight	21,434,145	6,171,786	1,779,715	tons $W_{fp} = V_{fp} * pw$
W ₁₁	Dewatered sediment weight	7,359,960	2,103,728	606,637	tons $W_{11} = W_{10} - W_{fp}$
Sediment Process Water					
V _w	Generated process water volume	11,668,293,955	3,380,469,721	974,802,447	gal $V_w = (V_4 - V_6 - V_{11}) * 202 \text{ gal/cy} + (V_{pt} + V_{clr} + V_{pp})$